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REAL LIFE SAVING OF ENERGY IN THE HOME BY THE USE OF A SOLAR HEAT COLLECTOR SYSTEM

P.M.J. Terpstra
Department of Agrotechnology and Nutrition
Section Consumer Technology and Product Use
Wageningen University
P.O.Box 8060
6700 DA Wageningen THE NETHERLANDS
Email: paul.terpstra@wur.nl

J.A.C. van Ophem
Social Sciences Group
Department of Economics of Consumers and Households
Wageningen University
Wageningen THE NETHERLANDS

W. D. Janssen
Wageningen University THE NETHERLANDS

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SUMMARY

In many European countries the energy used for hot water production covers a substantial part of the domestic energy requirement. Therefore, in the scope of sustainability, a number of technologies for reducing this share of domestic energy use have been developed. One of them is the use of solar energy with heat collectors linked to energy storage in water boilers.

In this paper the impact of this technology in Dutch homes will be discussed.

A research has been executed to investigate the real life energy saving in a sample of Dutch households (n=331) in which a solar heat collector for hot water production has been installed recently. The research analyses the energy usage before and after the installation of the system. In addition the behaviour, motives and attitudes of the households involved have been assessed in order to explain the differences changes in the observed energy use.

It is found that on average the external energy requirement for home

heating and hot water production is reduced after a solar heat collector has been installed and that this energy saving due to a solar energy system shows a wide variation among the households. In a substantial part of the households no energy reduction is observed. In a majority of the cases studied a solar energy system does not result in net financial benefits for the households.

DOMESTIC ENERGY CONSUMPTION AND ENERGY SAVING

Households are responsible for a substantial part of the total societies energy consumption. For the Netherlands a share of ± 18% for the direct energy consumption is reported (EnergieNed, 2000). On a European scale there are national differences but in general the household energy consumption is a substantial part of the total energy consumption as well (Henderson, 2002).

Energy, electricity and fossil fuels, is used for most activities at home. Apart from this direct energy consumption, energy is used for the production and elimination of products that are used in the home; the indirect energy consumption. For the Netherlands the quantity of indirect energy consumption is about equal to the direct energy consumption (Terpstra, 2002). The household direct energy consumption is increasing steadily. This concerns not only the total amount used but also the amount per household. In the Netherlands it rises on average 1.9% per household per year (Jeeninga and Uyterlinde, 2001).

The increasing energy consumption has several environmental impacts. Because the total reserves of fossil energy resources is fixed and the energy used is for the larger part non-renewable, there is a threat of depletion. Combustion gasses that are emitted during the use of fossil energy lead to global warming, the greenhouse effect. These and other effects are the motives to reduce the energy consumption in society and its domestic consumption too.

There are various approaches in the search for a sustainable energy management. Basic goal for all approaches is that energy should be used at a lower quantity or/and should be of a sustainable nature (e.g., wind, coal, tidal, etc). Lower energy consumption can be achieved by using less or consume more efficiently.

Some studies focus on solutions at a macro level e.g. industrial transformations, economic mechanisms and policy solutions, while other zoom in on individual consumers. Examples of the latter are technological solutions such as energy efficient appliances (Tweehuizen, Stork et al., 1982) or socio-psychological solutions like the behaviour and lifestyle changes of individuals.

The approach at the level of the household system, micro system, is not very common. Nevertheless there are important reasons for a consideration of the energy issue from a household system point of view. Households, as the smallest social units, are at the end of many production chains and therefore the household behaviour and dynamics are important factors affecting both direct and indirect energy consumption. While at the other hand the material infrastructure of a household and the household standards of living set the options and limitations for energy saving measures.

From a technical point of view households can use solar energy to reduce their consumption of primary energy. Producers of solar heat collector systems supply measurement data that specify the savings under defined standard conditions. In the domestic setting the energy saving depends on numerous, often not technical, factors. Therefore, the real saving can deviate substantially from the manufacturers specification.

In this paper the energy saving of solar heat collector systems in daily household practice will be analysed. For this purpose a research has been run among a sample of Dutch households with a solar heat collector. The aim of this research is twofold. First, to establish the real life energy saving both in m3 of natural gas and in money caused by the purchase and use of a solar heat collector. And secondly, to find out the profile of the owners of a solar heat collector in terms of economic and cultural capital, viz. socio-economic, socio-demographic and cultural characteristics of the respondents.

RESEARCH DESIGN

The main aim of the research is to get insight in the national saving potential of solar heat collector systems for domestic use. For this purpose it has to be known what amounts of energy are saved in real life conditions. And as the national saving potential depends on the savings per household and the number of systems installed, it has to be known also to what extent consumers will buy such systems; the potential degree of market penetration. For this purpose profiles of solar heat collector owners are of interest. The latter will show what factors affect the acquisition of the system.

To find an answer to these questions a survey has been conducted among a sample of owners/users of a solar heat collector. They were questioned about their energy consumption in the period before and after the purchase of the solar heat collector. In order to predict the potential penetration degree the sample questions were asked about typical motives and attitudes. The latter enables us to

derive user profiles of solar heat collector buyers.

A first set of questions was meant to characterise the households in the sample in terms of socio-economic and socio-demographic variables as family size and composition, household income, education, age and aspects of living conditions.

The second and most relevant set of questions focussed on energy consumption. Respondents were asked to supply the energy consumption data of the year before the installation of the system, the year of installation and the year thereafter as specified by their energy supplier. Questions about changes within the household that could interfere with the energy consumption were included also.

A third set of questions is related to the cost of the system; the costs of purchase, installation and maintenance and the financial subsidization by authorities. The sample was also requested to supply data about the real and expected financial savings of the system.

A last set of questions focussed on the motives for acquisition, environmental awareness and on related attitudes.

The mail questionnaire consisted of 39 questions and was sent to 800 owners of a solar heat collector in 2002. They were drawn from the population of this kind of equipment.

The selection of the sample in the survey was based on three criteria:

- Respondents should have purchased the system after 1995. This safeguards that they are able to recollect their acquisition motives and the situational conditions at the moment of purchase;
- The system shall be purchased before 2001, otherwise at the moment of the research the energy saving in the subsequent year could not be assessed; and
- And the users should have purchased the system themselves. Because in this situation it may be assumed that an accurate before-after evaluation is possible and relevant purchase motives can be retrieved.

Socio-economic and socio-demographic variables were not taken into account in the selection of the sample.

Three hundred twenty-four owners responded, which results in a response of more than 40%. Hundred thirty-one respondents supplied suitable data about their energy consumption. They differed not from the other respondents in terms of socio-economic and socio-demographic characteristics.

From the energy data received for each household the annual energy in the year before the acquisition, the year of acquisition and the year thereafter were

calculated.

Before the consumption in the three years could be compared several corrections had to be applied. Because the annual energy consumption depends on the weather, the consumption was corrected for differences in the weather of the years concerned. A correction was applied too for households where in the period of the investigation other energy saving appliances was purchased. And finally, there were corrections for situational changes that could affect the energy saving like a change in the family size.

The corrected annual consumption was used to calculate for each household the energy saving due to the solar heat collector system. They are reported in the next section.

RESULTS

The socio-economic and socio-demographic characteristics of the respondents differ from the average Dutchman or the distribution of the characteristics in the Dutch population. The latter can be established by the Statline database from the Netherlands' Bureau for Statistics (CBS). The respondents are predominantly men, 85 five per cent. The majority of the men and women are higher educated – 60 per cent of the men and 48 per cent of the women have completed tertiary education compared to about thirty per cent for both man and women in the Dutch population. More than 50 per cent of the households have a monthly gross household income of over 3500 euro per month, excluding holiday allowances, child allowances and the like. This means that they are to be found in the two upper deciles of the income distribution in the Netherlands. The majority of the household exist of dual earner households. Most men, 63 per cent work full-time and most women, 50 per cent, work part-time for at least 15 hours per week.

The fact that the respondents are relatively well to do is also reflected in ownership of cars and type of housing. Only six per cent of the households do not have the disposal of one or more cars and two or more cars are to be found in thirty-nine per cent of the households. The corresponding figures for the Dutch population are respectively twenty-four and nineteen per cent. Thirty-eight per cent of the household do live in a detached house and another 31 per cent in semi-detached house. The corresponding shares in the stock of houses in Netherlands are respectively fifteen and twenty-five per cent. All households are owner-occupiers of their house, as a consequence of the sample selection.

Singles are underrepresented, 4.5 percent compared to an overall share of thirty-three percent of the 6.5 million households in the Netherlands. Consequently, there is an overrepresentation of couples with and without children.

At the moment of purchase of the solar heat collector, the men and women are predominantly, to be found in the 35-55 age bracket, 64 per cent.

There are also cultural differences in values and attitudes as well as in behaviour between the solar heat collector users and the general picture of the Dutch population in this respect. However, these differences are not present in willingness to take collective actions or environmental concern. The former is low for both categories and environmental concern is high for both.

The solar heat collector users are more inclined to make financial sacrifices in order to protect the environment. Furthermore, they behave more environmentally friendly in the separation of all kinds of household waste as paper, glass, chemical stuff, fruit/garden/vegetables. They are more concerned with respect to environmental issues as the Dutch in general. They show a sense of public responsibility by membership of organisations as Green Peace, Amnesty, World Nature Fund, Doctors without border, Red Cross, Consumer Union and national environmental clubs.

Respondents (n=296) mentioned various and, in some cases, more than one reason for the purchase of a solar heat collector. Fifty-one households, 18 per cent, did so in order to save energy. The beneficial impact on the environment and on the depletion of non-renewable resources were reasons for 72, 24 per cent, to purchase such a system. Other reasons mentioned were: time to replace the old boiler (n=54); less costly because of subsidies and special offers (n=50); great interest in technique and innovations (n=37); attractiveness to use solar energy (n=34); new house or renovation of own house (n=14); acquainted with solar energy through work (n=14) and a suitable house (n=12)

As mentioned before, 128 households provided the necessary information to establish whether the purchase of a solar heat collector has led to energy savings.

On average the quantity of energy saved due to a solar heat collector amounts 214 m^3 of natural gas per household per year. This implies that the average savings of a solar heat collector is about 7 per cent of the total gas consumption used before the purchase of the solar heat collector.

The dispersion between households in natural gas savings is extremely high, the standard deviation amounts 569 m^3. Only 65 of the 128 households actually have saved energy in both years after the acquisition of the solar heat collector. Another group does not save in the year of acquisition but in the year thereafter. The other households achieved no saving and in a number of cases had higher energy consumption. Considering the evolution of the energy consumption after the acquisition of a solar heat collector, four categories can be discerned (Table 1).

Table 1 Response groups according to changes in energy consumption

	Declined gas consumption1 in the second year after acquisitions	Increased gas consumption1 in the second year after acquisitions
Declined gas consumption1 in the year of acquisition	Group 1 (n=65)	Group 2 (n=33)
Increased gas consumption1 in the year of acquisition	Group 3 (n=22)	Group 4 (n=8)

[1] Reference is the consumption of the year before acquisition of the solar heat collector.

In Table 1 it can be seen that in the year of the acquisition both an increase or decrease can occur and that in the year thereafter again both increase and decrease of energy consumption is observed.

Table 2 Average energy savings in m^3 of natural gas attributed to the solar heat collector

	Average, m^3	**Standard, m^3**	**N**
Group 1	474	555	65
Group 2	-42	295	33
Group 3	-44	404	22
Group 4	-495	328	8
Total	214	569	131

In Table 2 the average savings in m^3 is given for the four groups. It is interesting to mention that it appears that people with a higher energy-saving commitment in this sample do not save more energy than people with a lower energy-saving commitment.

In Figure 1 the costs of a solar heat collector in Dutch guilders excluding subsidies are related to the savings in m^3 natural gas. It appears that there is no straightforward positive relation between the two. So, more money spent on a solar heat collector system does not lead to more savings in m^3.

Table 3 contains the results of a break-even analysis in which average costs and savings are computed based on 2002 prices. In this analysis the expected technical life span of a solar heat collector is, based on expert knowledge, assumed to be 15 years. The evaluation calculation is done with and without subsidies for three different types of solar heat collector. It appears that on average a solar heat collector is not profitable, even after the deduction of subsidies. The pay-off period is more than the technical life span. Only in an estimated 39 per cent of cases, the solar heat collector is profitable.

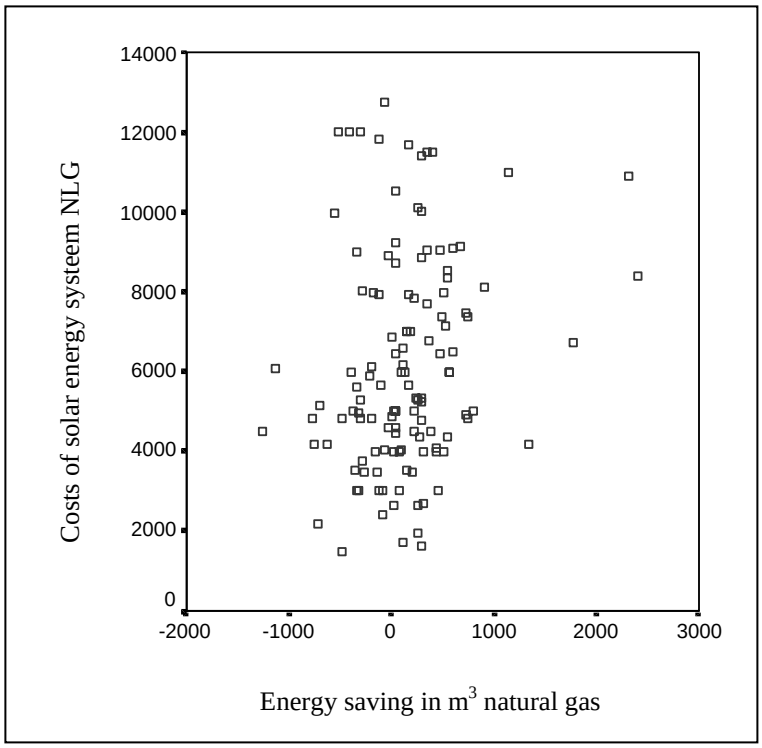

Figure 1 Natural gas savings in relation to solar heat collector expenses in euro, subsidies excluded

Table 3 A life span comparison of average costs and energy savings

Type of solar heat collector system	Costs of a solar heat collector (in €)	Costs of a solar heat collector after deduction of subsidies (in €)	Solar heat collector savings in period of 15 years (in €)
Standard system with storage	2.174,-	1.649,-	1.221,-
Compact system; no storage	2.450,-	1.712,-	738,-
Combined system	4.161,-	3.611,-	2.808,-

CONCLUSION AND DISCUSSION

This paper reports on research of which the aim is to establish the real life energy saving both in m^3 of natural gas and in money caused by the purchase and use of a solar heat collector and to find out the profile of the owners of a solar heat collector in terms of economic and cultural capital.

The respondents, who own a solar heat collector, belong to the strata with a higher economic and cultural capital. The socio-economic and socio-demographic characteristics of the respondents differ from the average Dutchman or the distribution of the characteristics in the Dutch population. The majority of the men and women are higher educated and to be found in the higher income groups. All households are owner-occupiers of their house.

There are also cultural differences in values and attitudes as well as in behaviour between the solar heat collector users and the general picture of the Dutch population in this respect. The solar heat collector users are more inclined to make financial sacrifices in order to protect the environment. Furthermore, they behave more environmentally friendly in the separation of all kinds of household waste. They are more concerned with respect to environmental issues as the Dutch in general. They show, more than the Dutch in general, a sense of public responsibility by membership of organisations and associations.

On average the quantity of energy saved due to a solar heat collector amounts 214 m^3 of natural gas per household per year. This implies that the average savings of a solar heat collector is about 7 per cent of the natural gas usage before the purchase of the solar heat collector.

The dispersion between households in natural gas savings is extremely high, the standard deviation amounts 569 m^3. Only half of the households in the research actually have saved energy in both years after the acquisition of the solar heat collector. Another group does not save in the year of acquisition but in the year thereafter. The other households achieved no saving and in a number of cases achieved higher energy consumption.

More money spent on a solar heat collector does not lead to more energy savings.

It appears from the real life situation that 39 per cent of the households do save money when a solar heat collector is acquired and when subsidies are deducted from the purchase price. On average, the solar heat collector is not profitable for households, even after the deduction of subsidies. The pay-off period is more than the technical life span.

In this paper and empirical research reported, we have applied an approach at the level of the household system, micro system. As said in the

introduction, there are important reasons for a study of the energy issue from a household system point of view. Households, as the smallest social units, are at the end of many production chains and therefore the household behaviour and dynamics are important factors affecting both direct and indirect energy consumption. While at the other hand the material infrastructure of a household and the household standards of living set the options and limitations for energy saving measures.

It appears from the results presented here that real life energy savings of a solar heat collector system are far less than predicted from a technical analysis. In the former, household behaviour and activities are taken into account, in the latter not. And from the household system approach, it appeared that there is not only a group of energy savers, but also three groups of increased energy users. This is contrary to what is expected from a technical analysis.

So, a household level approach is very useful in assessing the effectiveness and efficiency of certain policies to reduce domestic energy consumption.

From the results presented here, it can be concluded that the use of a solar energy system at home is at this moment not as efficient as anticipated. In fact, seen at the household level, driving in a car less frequently and not or less frequently taking a holiday by airplane, is probably a better alternative to reduce domestic energy consumption than the acquisition of a solar heat collector system.

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